DOCUMENT RESUME

ED 388 584 SO 025 504

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TITLE What's Up in Factories? Exploring the New World of Manufacturing. Teacher's Curriculum Guide.
INSTITUTION Thirteen WNET, New York, NY.
PUB DATE 94
NOTE 29p.; Support has been provided by the International Business Communications Council.
AVAILABLE FROM Great Plains National, P.O. Box 80669, Lincoln, NE 68501-0069 ($59.95 for set).
PUB TYPE Guides - Classroom Use - Teaching Guides (For Teacher) (052)

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS *Assembly (Manufacturing); Business; High Schools; Industrialization; *Industry; *Manufacturing; *Manufacturing Industry; *Mass Production; Social Studies; *Technology

ABSTRACT

This curriculum unit is intended for use in high school social studies, technology education, science classes, and in some career guidance classes. The lesson plans and activities are to help teachers present a comprehensive unit on manufacturing to their students. Activities provide hands-on, problem-solving, and cooperative work experiences. There are four lesson plans and a guide for setting up a factory visit. Lessons include: (1) "Why Study Manufacturing?"; (2) "The History of Manufacturing"; (3) "The Manufacturing Process"; and (4) "New Trends in Manufacturing." The unit also includes: a large colorful poster (not included here) for classroom display; a one-half hour videotape (not included here); a 28-item list of organizations, publications, and science and technology centers teachers may wish to consult; and a 25-item bibliography/filmography. (EH)

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TEACHER'S CURRICULUM GUIDE

WHAT'S UP IN FACTORIES?

EXPLORING THE NEW WORLD OF MANUFACTURING

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INCLUDES:

Historical Background and New Trends

Career Profiles

Step-by-Step Guide to Visiting Local Factories

Charts on "The Manufacturing Process" and on "Making an Athletic Shoe"

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Support for these education materials has been provided by IBCC

IBCC is composed of Japanese automobile and electronics trade associations.

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ACKNOWLEDGMENTS

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ABOUT THE FUNDER

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Established in 1990 as a nonprofit organization, International Business Communications Council (IBCC) is composed of major Japanese trade associations in the automobile and electronics fields. IBCC believes that, as a cornerstone of today's society and economy, manufacturing industries have an especially important role to play in improving the life of their communities and in fostering a broader understanding of the borderless, interdependent world in which we live. In carrying out its mission, IBCC works together with counterpart organizations around the world in such fields as education, media, philanthropy, community service, and cross-cultural exchange.

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To the Teacher

Introduction

In Kentucky, workers relax after hours and brainstorm ways of working more efficiently as a team. In Michigan, one autoworker stops the entire assembly line after discovering a defective door part. In Wisconsin, high school students receive on-the-job training at a local printing plant as part of their curriculum. Such examples might not fit our commonly held image of factory work. But they show just how much factories are changing.

What's Up In Factories? Exploring the New World of Manufacturing takes teachers and students on a fascinating journey to examine new trends in manufacturing as well as its impact on all our lives.

Factories provide an economic base for many of our communities. They offer career opportunities for managers, engineers, and designers as well as for those who are not college bound. There is a fresh wind in manufacturing today that will make as much of an impact on production methods as Henry Ford's assembly line did in the early 1900s. Unlike the assembly line, however, this new approach, known as lean production, emphasizes cutting inventories to the bone, producing only what is ordered, and having teams of workers actively participate in solving problems and improving the quality of the product. While the assembly line helped to make the United States the world's leading manufacturer, many believe that lean production can help the United States regain its leading role. For their efforts, workers in lean production lines receive good salaries and the pride and satisfaction that comes from creating something with their own hands. They also participate in making quality goods that help their companies prosper.

About This Guide

This curriculum unit is intended for use in high school social studies, technology education, and science classes. It is also useful in career guidance classes. The lesson plans and activities in this guide have been designed to help teachers present a comprehensive unit on manufacturing to their students. A variety of hands-on activities will allow students to experience the many new trends being implemented in factories and will also serve to enhance their problem-solving skills and their ability to work as a team.

These materials include four lesson plans and a guide for setting up a factory visit. Each lesson is intended to take one class period and includes

- **objectives**, which provide measurable goals for each lesson;
- **motivation**, which familiarizes students with the lesson's themes;
- **presenting the lesson**, which provides teachers with a method for presenting the material;
- **lesson wrap up**, which provides discussion questions or activities that help students assess and extend the main points of the lesson;
- **student activity sheets** to be duplicated and distributed to students, which contain activities that support and extend the lesson's themes;
- **background information**, which provides teachers with the background material necessary to conduct the lesson;
- **vocabulary**, which provides definitions of unfamiliar terms;
- **advance preparation**, which suggests items teachers will need for each lesson;
- **optional resources**, which provides books and videos that correspond to the lesson's themes.

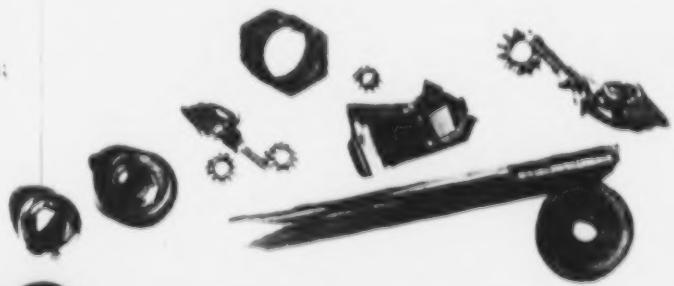
This curriculum package also includes a colorful **poster** for classroom display.

Scheduling

What's Up In Factories? is intended to take four to five hours of class time in addition to the factory visit. (Note: Since the factory visit is the focal point of this unit it is important to devote class time to tour a factory.) Because of time constraints some teachers may not be able to commit this amount of time to the unit. If that is the case, you have several options for covering the material:

- You may combine two lessons (Lessons 1 and 2; Lessons 3 and 4) into one class period each and choose from among the activities presented;
- You might have students work in small research groups, assigning one lesson to each group to present to the class. Provide groups with the background material and student sheets from the guide to help them in their presentation. Allow groups 20-25 minutes each to present their findings.
- Assign the material in Lessons 1, 2, and 3 as homework assignments. Present Lesson 4 as preparation for the factory visit.

We hope you and your students enjoy *What's Up In Factories? Exploring the New World of Manufacturing.*



LESSON 1

Why Study Manufacturing?

Objectives

Students will

- discuss the importance of manufacturing in society.
- explain several ways manufacturing affects their lives.
- evaluate the importance of teamwork in completing a task.

Advance Preparation

You will need

- a copy of Student Activity 1, "Examining a Manufactured Item," for each student (page 2).
- one retractable ballpoint pen for demonstration purposes.
- several items that students can easily disassemble such as flashlights, fountain pens, mechanical pencils, or other simple manufactured items.
- pliers; phillips and flathead screwdrivers (if necessary).

Vocabulary

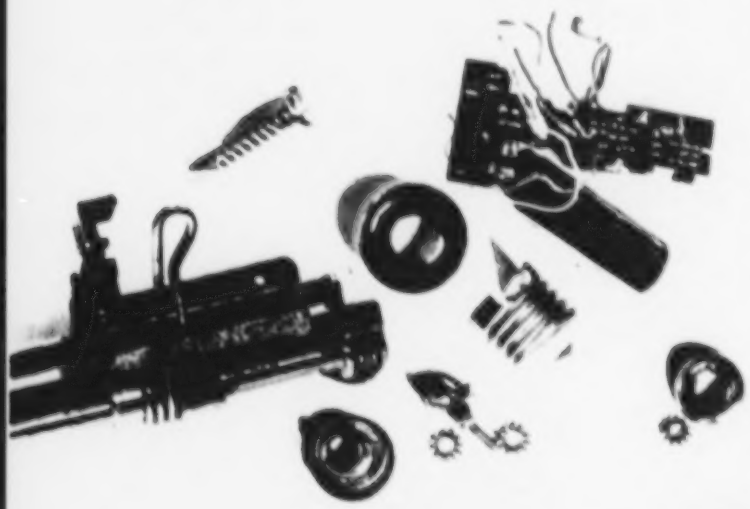
The following terms are referred to in this lesson. Definitions can be found in the Glossary, page 25.
engineering, factory, manufacturing, technology

Optional Resources

Books

- *The Way Things Work*
- *What's What: The Visual Glossary of the Physical World*
- *Made in America: Regaining the Productive Edge*

(See Bibliography, page 24)



MOTIVATION

Note: This lesson is designed to take one class period (45 minutes). You may, however, want to devote a second class period if discussion or the hands-on activity requires more time.

Write the word ***manufacture*** on the chalkboard. Discuss the term with students, and have them formulate their own definitions. Examine various possibilities, leading them to conclude that ***manufacturing is the transformation of materials into usable products.*** You might also point out that manufacture is derived from the Latin words ***manu factus***, meaning ***made by hand.***

Hold up a simple manufactured item, such as a retractable ballpoint pen, and partially disassemble it. Ask students to identify its features and the materials used to make it. Ask them to suggest the steps involved in transforming the raw materials into the finished product. They might also speculate about the different jobs people perform in making the pen. Point out that though people often take such simple items for granted, transforming raw materials into parts needed to produce the pen took engineering, design, and technology as well as time, money, and effort. Ask students to look around the room to try to find an item that is ***not*** manufactured. Ask them to discuss the various manufactured products they use every day and to consider their usefulness.

PRESENTING THE LESSON

The activity outlined on page 3, "Examining a Manufactured Item," provides students with an opportunity to investigate the parts and materials that go into the manufacture of a product. Have students work in groups of four to five for this activity. Distribute one manufactured item, tools, and several copies of Student Activity 1 to each group. Review directions on the student sheet. Remind groups that they will have 20 minutes for this activity. When students have completed the activity, allow them time to share what they have learned with the rest of the class.

LESSON WRAP UP

Have students share their answers to the follow-up questions on Student Activity 1. Then have students work in groups of five or six. Allow each group five minutes to brainstorm about why an understanding of manufacturing is important to the following: auto mechanic, banker, consumer, farmer, politician, stock broker, student. Have groups share their ideas with the rest of the class. To further extend this lesson, you may suggest that students find newspaper or magazine articles related to manufacturing and consider how information in the articles could affect them or their community.

Examining a Manufactured Item

Everyday items of all sorts are produced from specially made parts. By examining and taking apart a manufactured product, you can begin to understand the roles that design, technology, engineering, marketing, and economics play in manufacturing. With your group solve the following problem.

THE PROBLEM

You and other members of your team are engineers with Company ABC. The head of your department has asked you to examine in detail a product made by a competitor. The department head needs this information in 20 minutes.

Before You Begin

Read through **Now Do This** before you decide how your team will work together and how you will gather and share information.

- Will each of you perform a single task?
- Will all of you share in every task?
- Will smaller groups perform individual tasks?
- Will one person disassemble or assemble while another records?

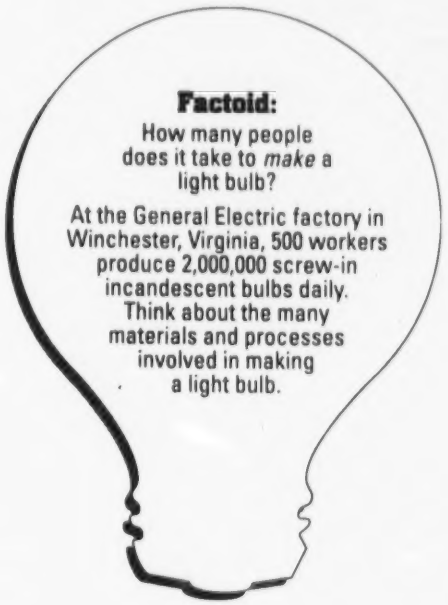
Now Do This

1. Write a description of the product and how it is used. Also, include its approximate price.
2. Take apart the item, using appropriate tools where necessary. Identify and describe the various parts and the materials each is made from. Also, describe how each part was made (stamped, molded, etc.).
3. Note each step you perform and any details that may be important such as how to hold a part. Number each part so that you can easily reassemble the item.
4. Give a step-by-step description of how the item is assembled. You can make a sketch or assembly drawing. As you reassemble your item, you will better understand the function of certain parts.

Follow Up

When the task is completed, evaluate how your team worked together.

1. Was working with a team an effective way to work? Do you think you would have accomplished as much working alone?
2. Were the methods that your team used to complete the task successful?
3. How did your team gather and share information? How was information communicated during the activity?
4. What did you contribute to the team effort? Are you satisfied with the work your team did? If you were to work together again, what would you do differently to improve team performance?
5. How would you have gone about assembling your item if there had been 10 of them? 10,000 of them?
6. How might the study of manufacturing benefit you?


Factoid:
How many people does it take to *make* a light bulb?
At the General Electric factory in Winchester, Virginia, 500 workers produce 2,000,000 screw-in incandescent bulbs daily. Think about the many materials and processes involved in making a light bulb.

LESSON 2

The History of Manufacturing

Objectives

Students will

- examine the history of manufacturing.
- describe the rise of the factory system and mass production and compare them to prior methods of production.

Advance Preparation

You will need

- "Looking Back at Manufacturing," (pages 6-7).
- a copy of Student Activity 2, "Manufacturing Times," for each student (page 5).
- an overhead projector (optional).

Vocabulary

The following terms are used in this lesson. Definitions can be found in the Glossary, page 25: *AFL, arbitration, assembly line, CIO, division of labor, Great Depression, Knights of Labor, mass production.*

Optional Resources

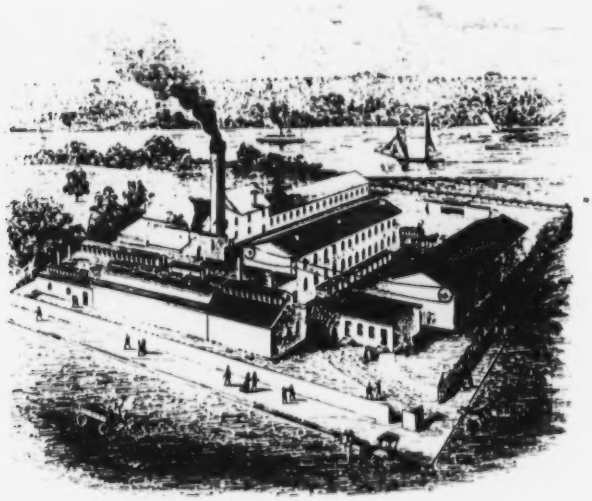
Books

- *Bread and Roses: The Struggle for American Labor, 1865-1915*

Films

- *The Deming of America*
- *The Life and Times of Rosie the Riveter*
- *Sit Down and Fight —Walter Reuther and the Rise of the Auto Workers' Union*

(See Bibliography, page 24.)



MOTIVATION

This lesson will give students a historical basis for understanding manufacturing today. Students already have some familiarity with the topics presented here from previous course work. Draw on this knowledge by having students share what they know.

Tell them they will work in groups to pool their knowledge about one of four topics. Have students work in groups of four to five, and assign one topic to each group. The topics are

- working conditions in factories (late 1800s);
- Henry Ford and mass production (about 1908);
- the rise of unions (1930s - 1940s);
- manufacturing today (wages, skills, unions, benefits).

Allow groups about 10 to 15 minutes to share what they know about the topics. Then have each group present its findings to the rest of the class. After each presentation, allow other students the opportunity to add information or to ask questions. Tell the class that they will learn more about the topics they have discussed.

PRESENTING THE LESSON

Use the historical overview, "Looking Back at Manufacturing," (pages 6-7) in one of several ways. You may

- use the information to present a lecture to the students;
- duplicate and distribute the page for students to read;
- use an overhead projector to display the page for students to read and discusss.

After the presentation ask students to identify areas about which they would like to learn more or have questions.

Distribute Student Activity 2, "Manufacturing Times," to students, and have them read the articles. Have students, working alone, with a partner, or with a group, complete the activity as a homework assignment. Completed assignments may be displayed on the bulletin board.

LESSON WRAP UP

Use the following questions to stimulate class discussion.

1. Describe the rise of the factory system and mass production. Compare these systems with prior methods of production.
2. What was factory work like in the late 1800s? Early 1900s? The 1930s to 1940s? What is factory work like today?
3. Would you consider working in a factory? Why or why not?

ALL THE NEWS FROM HISTORY

Manufacturing Times

1793·1914·1944 EDITION

First U.S. Textile Factory Built

PAWTUCKET, R.I. – 1793

Here on the Blackstone River, the firm of Almy, Brown & Slater has built the first textile mill in the United States. The factory, as it is called, will produce cotton cloth. Children age seven to twelve have been hired to operate 250 spindles on the looms in the wood-frame building.

Samuel Slater, an Englishman who joined the firm three years ago, is credited with making the mill a reality. Emigrating in 1789, he brought with him secret information about British textile technology, which American manufacturers were eager to have. English law forbids the export of machinery drawings or models. Slater relied on memory to copy Arkwright's spinning frame, a machine that produces 48 uniform cotton threads at a time.

Until now American cloth has been hand-woven by artisans and home manufacturers. The introduction of this technology and the establishment of textile factories could result in a dramatic drop in the price of cloth, as some observers are predicting. If the Almy, Brown & Slater venture is successful, it could change the nature of American textile manufacturing.

Create Your Own Newspaper

With a partner or a group, create a page for **Manufacturing Times**. Choose one of the time periods highlighted in this issue or another period of your choice. Research and write several articles that pertain to manufacturing in that era. Also write a Help Wanted advertisement for factory workers, including job requirements, hours, benefits (if any), skills and education needed, and wages. Create a bulletin board display of your finished work.

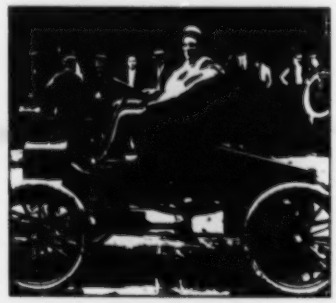
PAY RAISE FOR AMERICAN WORKERS: HENRY FORD PROMISES $5 PER DAY

DETROIT — January 1914.

Automobile magnate Henry Ford announced a generous wage of $5 per day for all workers, about twice what other workers in the industry are making. He also plans to reduce the work day from nine hours to eight.

The raise comes soon after Ford scored record profits of more than $10 million in 1913. The company's Model T, launched in 1908, has indeed proved to be the popular "motor car for the multitude." Ford's success is also due to the great increase in efficiency created by his innovative system of mass production, which has reduced the time needed to assemble a vehicle from 14 hours to a mere hour and a half.

The effect of the raise on workers is expected to be positive. By paying them more than workers in other companies, Ford hopes to reduce turnover and gain their loyalty as customers as well as employees. In exchange for his generosity, however, Ford demands that workers be of good moral character, a requirement enforced by close supervision of his workers both on and off the job.



The Bettmann Archive

HENRY FORD

FOR ROSIE THE RIVETER — NUMBERS UP, WAGES LAG

WASHINGTON, D.C. — November, 1944.

While American men in the armed forces are fighting overseas, an unprecedented number of women have joined the work force. According to the current issue of **Monthly Labor Review**, women in the labor force increased by 4,400,000 since the United States entered the war in late 1941. This number represents 3,000,000 more women than it is estimated would have been working under peacetime conditions.

These women ordinance workers, popularly referred to as Rosie the Riveter, are vital to the war effort. Shipyards, aircraft factories, and auto plants would be crippled if women had not stepped in to fill the shoes of men who left to fight. Although about 60 percent of the women working today were employed before the war, few were working in these industries. In 1941 only 143 women worked in seven aircraft factories. A year later more than 65,000 women were employed by the same factories.

Women in heavy industry earn quite a bit more than they did in their "ladylike" jobs. Some earn more in a day than they used to earn in a week. Yet studies show that they are still paid less than men doing the same job, about $31.21 per week compared to $54.65 for men. Nonetheless, women are enthusiastic about their new work and their role in the war effort. "Every time I test a batch of rubber, I know it's going to help bring my three sons home quicker," said one rubber plant worker. For many of the women, the camaraderie of factory work is often cited as a positive element of their wartime employment.

A Revolution in Manufacturing

The Industrial Revolution began in England about 1750 when critical innovations and great inventions created better ways of meeting a growing demand for textiles and other products. In America most products were made with hand tools by individuals in their homes or by artisans in small shops. Gradually people realized that it was more efficient to break down the manufacture of a product into separate steps. Rather than make a product from start to finish, each home worker would do one or two steps in the production process. This method became known as the **division of labor**. The division of labor and the introduction of machines such as the spinning jenny for producing yarn made it logical for work to be done in a central location, and so the factory, which gathered workers and machinery to complete all of the steps of production under one roof, was born.

LEWIS HINE/THE BETTMANN ARCHIVE

Child labor in a Carolina cotton mill, 1908.

Growth of the Factory

During the 19th century, the United States industrialized rapidly and spectacularly. In 1851, at the Great Exhibition in London, American goods, from Singer sewing machines to McCormick farm equipment, gained widespread admiration for their inventiveness. They were products of what became known as the American factory system. The system was characterized by

- mechanization of manufacturing processes, that is, using machines to do work that formerly had been done with hand tools;
- use of uniform, interchangeable parts — a concept devised by Eli Whitney — by which a broken machine part could be easily replaced with an identical part;
- a more complete division of labor in which the manufacturing process is broken down into a number of smaller steps, each of which is carried out by an individual.

With a growing work force and vast natural resources, U.S. manufacturing surpassed agriculture in economic importance soon after the Civil War. By the start of the 20th century, "smokestack America" had become the world's industrial giant.

The Rise of Mass Production

During this expansive period, Henry Ford developed a system of mass production for assembling his famous "Model T." In the early 1900s, automobiles were put together by skilled craftsmen and fitters who carefully hand-tooled each part — a time-consuming, expensive process that seemed necessary for such a complex product. Setting out to design a simple car "for the multitude," Ford built on methods already being used by some factories to produce items quickly and in large quantities. In applying those methods to the automobile, Ford

- used new, easier-to-work, more reliable metals and alloys;
- implemented the use of interchangeable, standardized parts that could be assembled quickly;
- broke down complex operations into simple tasks and hired unskilled workers to do them.

In 1913, five years after introducing the Model T, Ford put an assembly line into operation. The auto was constructed by workers as it passed them on a simple, motor-driven conveyor. In a complex and much-admired engineering feat, workers were provided with a continuous supply of parts to keep the production line moving. Henry Ford and his engineers dramatically decreased the time it took to build a car, from 14 hours to a little more than an hour and a half, and so reduced its cost. By 1920 one out of every two cars on the road was a Ford.

The Model T sold for $850 when introduced, but by 1926 the cost had dropped to less than $300. In addition, by raising his workers' salaries to almost double the usual rate, Ford helped create a middle class of workers who could afford to buy his cars.

A New Industrial Order

It is no exaggeration to say that Ford's remarkable success had great impact on the manufacturing world. It stimulated demand in other industries such as petroleum and rubber and helped lead to a nationwide highway system. Ford's assembly line was adopted by other manufacturers, and his success spurred on his competitors. The automobile became a mainstay of American industry and helped shape the world of things to come.

U.S. manufacturing emerged after World War I (1914-1918) stronger than ever. Although the Great Depression slowed growth in the 1930s, U.S. factories were prepared to play a major role in World War II (1939-1945). During the war, in which men fought overseas and millions of women worked in factories, American industry produced huge numbers of aircraft, ships, and war equipment.

At the end of World War II, U.S. industry was producing up to 60 percent of all the world's manufactured products. During the next quarter of a century, it would continue to grow and diversify as thousands of industries sprang up to meet consumer demands for radios, television sets, and refrigerators.

The Place of the Worker

The factory system was a key element in initiating widespread changes during the 18th and 19th centuries. But factory workers were not beneficiaries. In 1840 they worked an average of 11½ hours per day, six days per week. Child labor was common in factories, where conditions were often dangerous.

In fits and starts, American workers organized into unions, overcoming the opposition of government and industry. The first important national union, the **Knights of Labor** (founded in 1869), fought for the adoption of industrial safety measures, a weekly pay law, equal pay for equal work for both sexes, and arbitration instead of strikes. Membership was not restricted according to race, religion, or gender.

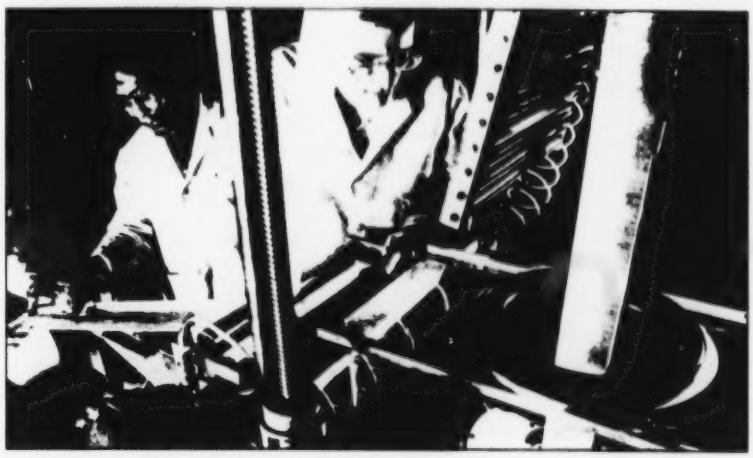
Over the years other unions such as the **American Federation of Labor** (founded in 1886) and the Congress of Industrial Organizations (founded in 1938) were formed. By the 1940s, these and other unions had grown in power and represented one third of the work force.

Factory workers faced problems besides low wages. Finding new, inexpensive ways to produce goods was management's prime concern. Principles of scientific management, developed in the early 1900s, were designed to improve worker efficiency by speeding up the work process. Such methods, however, turned many factory jobs into unpleasant, boring tasks that did not give workers the satisfaction of exercising a skill. In recent years, U. S. manufacturers have placed more importance on job satisfaction and worker participation in the decision-making process. These decisions have helped to increase productivity and product quality and have given workers a sense of fulfillment.

Recent Trends

From 1945 until the oil crisis of 1973, U.S. manufacturing experienced unrivaled success. But by the mid-1970s, profitability had begun to decline despite efforts to use sophisticated machines and even robots. Quality was slipping, and the needs of workers were being neglected. The automobile industry was especially hard hit when, in the 1980s, Japanese auto makers began to cut into U.S. auto makers' profits by improving the system of mass production and focusing on quality. By the 1990s, however, American companies were once again seeking ways to meet workers' needs and to improve the manufacturing process.

These new approaches and trends will be examined in greater detail in Lesson 4.



COURTESY OF W.R. GRACE & CO.

Researchers process polymer mixtures into layered films.

LESSON 3

The Manufacturing Process

Objectives

Students will

- identify materials that go into the manufacture of an item and the processes that are used
- discuss the basic steps that go into the manufacture of an item.

Advance Preparation

You will need

- several athletic shoes for demonstration purposes;
- "The Manufacturing Process" chart (page 9);
- Student Activity 3, "Making an Athletic Shoe" (pages 10-11);
- an overhead projector (optional).

Vocabulary

The following terms are referred to in this lesson. Definitions for these terms can be found in the Glossary, page 25: *casting, chemical process, forming, mechanical process, prototype, separating.*

Optional Resources

The following resources will help to extend the topics presented in this lesson.

Books

- *Motorcycle: The Making of a Harley-Davidson*
- *Well-Made in America: Lessons from Harley-Davidson on Being the Best*

Films

- *Challenge to America*

(See Bibliography, page 24.)

MOTIVATION

Have students work in groups of five to six. Distribute an athletic shoe to each group, and have students identify the materials used in its manufacture. They should list both raw materials such as rubber and manufactured products such as metal eyelets. Have groups determine how the materials were processed—that is, molded, cut, or stamped—before becoming part of the shoe. Finally, ask each group to formulate questions about how the shoe is manufactured.

After 15 minutes, have groups share their findings with the class. List questions on the chalkboard. Tell students that many of their questions will be answered as they learn more about the manufacturing process.

PRESENTING THE LESSON

Student Activity 3, "Making an Athletic Shoe," offers students a step-by-step explanation of the processes involved in manufacturing. Duplicate and distribute the page to students. Allow them to study the page and draw conclusions, comparing them to their original ideas.

Now display "The Manufacturing Process" chart using the overhead projector or duplicate and distribute it to students. Ask them to relate each stage of the basic manufacturing process to the manufacture of the athletic shoe.

LESSON WRAP UP

Discuss the questions that students formulated in the Motivation part of the lesson. Use these questions to stimulate discussion.

1. What did you learn about the manufacture of athletic shoes?
2. What are some features you look for when you buy an athletic shoe? How do these features benefit consumers?
3. If you were designing an athletic shoe, what features would you build into it? Who would be your target consumer? Who would you choose to endorse your shoe?

Illustration by Susan Detrich

THE MANUFACTURING PROCESS

RAW MATERIALS

These are obtained by drilling (i.e., petroleum), mining (i.e., iron ore, copper), or by harvesting (i.e., lumber). Then they are converted into standard stock (steel, lumber, leather, rubber) by . . .

CHEMICAL PROCESS

Raw materials are refined through chemical reactions or through heating. For example, leather is tanned using a chemical process; simple compounds are combined to form plastics.

MECHANICAL PROCESS

Raw materials are changed through mechanical operations such as cutting or crushing. Trees, for example, are cut into lumber; rock is crushed to make gravel.

INDUSTRIAL PRODUCTS

are created from these materials by one or more of the following processes:

Casting and Molding

the pouring or forcing of a liquid material into a mold, where it hardens. A porcelain bathtub is made from this type of process.

Separating

the changing of the material's size or shape by cutting or shearing excess material. Pattern pieces for athletic shoes are cut during the separating process.

Conditioning

the use of chemical action or mechanical force to change the internal properties of a material. Firing a clay bowl in a kiln is an example of conditioning.

Forming

the permanent shaping of an industrial product using a die, mold, or roller. Disposable plastic plates, steel truck axles, and other products are created by forming.

Assembling

the temporary or permanent joining of parts. Toasters, dresses, automobiles, athletic shoes, and computers are examples of products that are assembled.

Finishing

the refining or protecting of a product's surface. The paint that coats a new automobile or the glaze on a ceramic bowl are examples of finishing.

All these steps result in a finished product.

Making an Athletic Shoe

You're looking for new athletic shoes. You pick up a shoe and turn it around. You note the style, color, lights, and all the other features. You may wonder, "How did they put this shoe together?" Let's take a look at how an athletic shoe is manufactured.

1

STEP 1

Athletic shoe companies employ designers who first conceptualize athletic shoes in drawings. The drawings are then used by a design team to make a three-dimensional model that is sculpted and painted. The design determines the shoe's quality and what it will cost to manufacture. Designers incorporate suggestions from market researchers as well as from previous customers and professional athletes. Designers often work with chemical engineers who may develop special materials for shoe soles and linings.

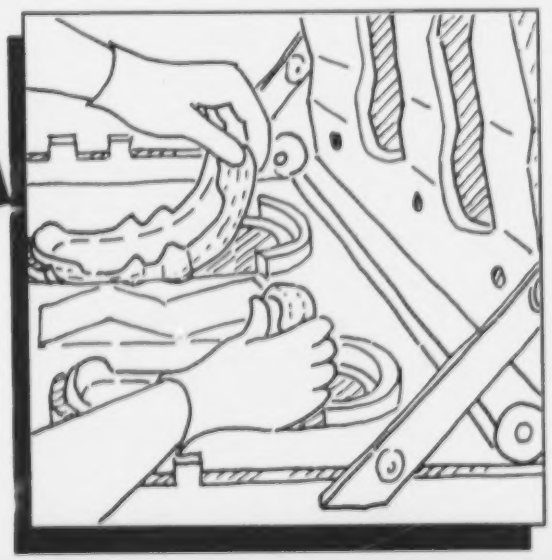
STEP 2

A pattern maker breaks down the model into its parts: the top of the shoe, called the upper and the sole or bottom of the shoe. Using a model of a foot, called a *last*, a pattern maker crafts all the different pieces of the sole and upper. Soles and uppers are made in standard sizes — size 8 or 9 in men's and size 6 in women's. Patterns for other sizes are graded, or proportionally enlarged or reduced, using a machine or computer. The completed model or *prototype* is then tested to see whether it meets certain standards.

2

STEP 3

When the prototype is given final approval, production of the shoe begins. At the factory, personnel and machinery are prepared to produce the new design. Workers use machines to cut or mold the soles, wedges, and midsoles from large sheets of rubber or synthetic rubber. These layers are joined together and act as cushioning between the upper and the sole.



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illustrations by Susan Detrich

6

STEP 6

At the soling area factory workers size and trim the sole and match it to the upper. They bond it to the upper by means of pressing, gluing, or riveting. Then they send the completed shoe to a finishing stage where dirt is cleaned off, linings and laces are attached, and the shoe is inspected.

STEP 5

Factory workers in the lasting area hang the finished uppers according to shoe size and then pull them over lasts in order to shape the shoe. They insert the heel cup, box toes, and shanks into the lining to give the shoe strength. They then send the uppers to the soling process.

5

STEP 4

Factory workers in the fitting room cut each component of the upper from leather, plastic, nylon, or another material, often using large die-cutting machines. Leather may be hand-cut to avoid waste. Sewing machine operators or computerized sewing systems then stitch together the parts of the upper. After sewing, eyelets, buckles, velcro, or other attachments such as pumps and lights are added.

4

Factoid:

Lights on running shoes are an innovation inspired by the need for safe running at night. But are they new? People in South America and the West Indies often tie blinking cucuyo fireflies to their shoes at night to help light their way along dark paths.

LESSON 4

New Trends in Manufacturing

Objectives

Students will

- examine recent trends in manufacturing.
- predict how these trends may affect American workers.
- discuss how recent manufacturing trends might affect their own lives.

Advance Preparation

You will need

- "New Trends in Manufacturing" summary (pages 14-15).
- a copy of Student Activity 4, "Nuts and Bolts," for each group (page 13).
- a copy of Student Activity Sheet 5, "Profiles," for each student (pages 16-17).
- an overhead projector (optional).
- 10 small bolts, 30 washers (10 large, 10 small, and 10 lock washers if possible), and 10 nuts for each group.

Vocabulary

The following terms are used in this lesson. Definitions for these terms can be found in the Glossary, page 25: *built-in-quality, just-in-time, kaizen, kanban, lean production, quality circle.*

Optional Resources

Books

- *The Goal*
- *The Machine That Changed the World*

Films

- *Challenge to America*
- *The Deming of America*
- *We Do the Work # 403*

(See Bibliography, page 24)

MOTIVATION

The activity on Student Activity 4, "Nuts and Bolts," will provide students with hands-on experience of mass production as well as introduce some of the recent trends associated with lean production. Have students work in groups of seven or eight. Distribute the bolts, washers, and nuts and a copy of Student Activity Sheet 4 to each group. Allow groups about 15 minutes to complete the activity. Ask groups to share their experiences. Group innovations will vary and may include situating themselves so that the operation can move more smoothly, one person assembling all the washers, everyone taking responsibility for the quality of the product, and putting two assembly lines into operation. Then tell students that their experience with this activity is modeled on recent trends in manufacturing. Tell them they will learn more about such trends in this lesson.

PRESENTING THE LESSON

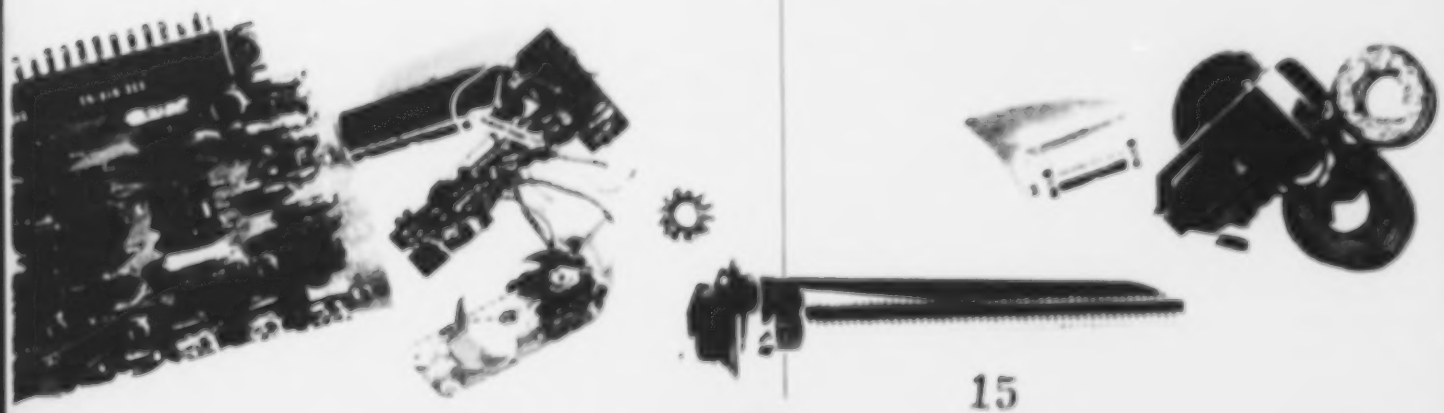
Use the summary, "New Trends in Manufacturing" (pages 14-15), in one of several ways. You may

- use the information to present a lecture to the students;
- duplicate and distribute the page for students to read and discuss;
- use an overhead projector to display the page for students to read and discuss.

Ask students how they would refine the "Nuts and Bolts" activity based on what they learned about new trends in manufacturing. Then discuss how some of the principles of lean production could be applied to activities or procedures in school, home, or community.

LESSON WRAP UP

Point out that the trend in manufacturing is to put more emphasis on the role of the worker and to obtain worker input. Distribute Student Activity 5, "Profiles" to students. Have them read the profiles as a homework assignment. Then discuss how the people featured in the profiles compare with the images they had of factory workers.



Nuts and Bolts

Manufacturers throughout the world are continuously looking for ways to improve production in their factories. In traditional mass production, new ideas and new work methods were generally implemented by supervisors and managers. Today, however, line workers are being asked to come up with ideas and innovations to improve the quality of the product and make their jobs more efficient.

THE PROBLEM

You and your team are assembly-line workers in Company XYZ. Your line manager has given you a new product to assemble. You will assemble the product according to the manager's instructions. Then you will brainstorm ways to improve the overall production.

The product is a bolt with three washers and a nut that holds the washers firmly in place. The diagram shows how the product should be assembled and what the finished product looks like.

Special thanks to Fifth Hour Welding Class at Hempstead High School, Dubuque, Iowa, for helping to test and refine this activity.

Before You Begin

Each team member should choose one of the jobs below.

Task 1: Place small washer on bolt and pass to position 2.

Task 2: Place large washer on bolt and pass to position 3.

Task 3: Place lock washer on bolt and pass to position 4.

Task 4: Tighten washers onto bolt with a nut.

Task 5: Check the quality of each product. Any piece that does not meet the standards shown in the illustration should be sent to position 6.

Task 6: Rework any defective products to bring them up to acceptable standards.

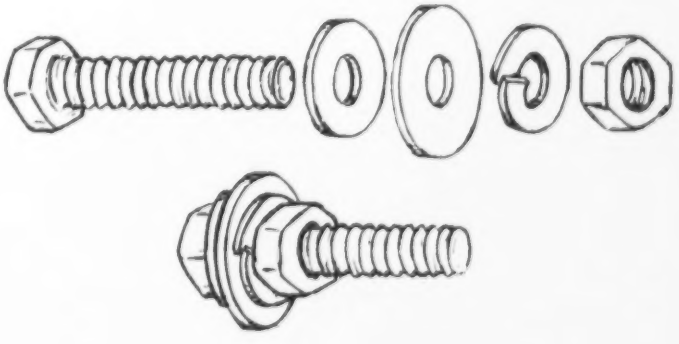
Task 7: Oversee the line production to make sure the assembly process runs smoothly.

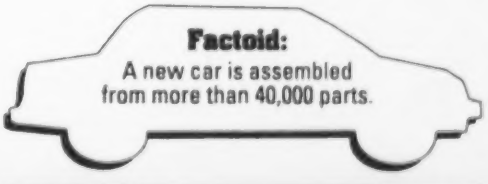
Task 8: Supply each position on the line with needed parts.

Now Do This

1. Assemble 10 bolts with washers and nuts. Time how long it takes you.
2. When you have finished, discuss and devise ways of improving your production.
   - Is there a better way of distributing materials?
   - Is there a better way of arranging the line to make the flow of work smoother?
   - Is there a better way of assembling the item?
   - Is there a way of cutting down on the number of people involved?
   - How can you improve the quality of the item in order to make an inspector and rework team unnecessary?
3. Do the activity again, incorporating the ideas of your teammates. Discuss how efficiency can be improved further.
4. Implement your ideas. Try the activity again.
5. Compare the last effort with your first try in terms of product quality and the number of people and time it took to produce. Share your observations and findings with other groups.

Diagram





Throughout history, technology, inveptions, innovations, and ideas improved the manufacturing process. In the late 1800s, Frederick Taylor's principles of scientific management, which made the workplace and the worker more efficient, were adopted by many manufacturers. In the early 1900s, Henry Ford's system of mass production revolutionized the way products were manufactured. As time went on, others began to use these systems, build on them and refine them.

Innovations in Japan

In the 1930s, Kiichiro Toyoda began to adapt Ford's ideas to his small automobile manufacturing operation in Japan. Because of the company's small volume of production, large inventories were something Toyoda could not afford. So his automobile assembly line was supplied with only the items it needed only when it needed them. The system of production management conceived by Toyoda was called **just-in-time**. In this system, each process or step produces only the kinds and quantities of items for the immediate use of the next process or step.

COURTESY OF TOYOTA MOTOR MANUFACTURING U.S.A., INC.

The Kanban card indentifies the parts needed for the next step.

In the 1950s, many Japanese industries adopted the ideas of an American consultant, W. Edwards Deming. Deming stressed the quality of the product and the manufacturing process.

At the same time, other systems instituted by Taiichi Ohno, Toyota's production manager, helped to refine just-in-time production into a comprehensive system of manufacturing called the Toyota Production System. Ohno raised productivity at Toyota by setting up each assembly line to produce needed items in a timely manner. By involving employees in the continuous process of making better products more efficiently, he ensured that quality was built into each component at each process in the sequence.

Elements of Ohno's system were widely emulated throughout Japanese industry and have recently begun to be implemented throughout the world. The system is often referred to as **lean production**. This term is used because less of everything—materials, equipment, people-hours, time, effort, capital—is required to produce the same quantity that traditional mass production generated. Although it may take years to put lean production into operation, its advantages have led many American companies to incorporate its principles.

Lean Production vs. Mass Production Push vs. Pull

Let's examine how lean production and mass production differ. In traditional mass production, hundreds of thousands of parts and materials are ordered and stored in supply houses. Supplies are continuously fed to the assembly line and as one process in the sequence is completed, the parts or materials are automatically sent on to the next process in the sequence, regardless of whether that next process is ready for them. In mass production, the maximum production output is extremely important, and the moving assembly line is never stopped, even when a defect is found. Defects are identified by inspectors when the finished product comes off the assembly line. Defects are corrected by a special team of mechanics whose job is to "rework" the product. Finished products are shipped to customers or stored in warehouses until orders come in. Mass production is a "push" system. Output from the first process in the sequence drives the second process and so on.

In contrast, lean production is a "pull" system that is driven by the order from the customer—the last step in the process. In lean production, each process is the "customer" for the preceding process. Each process is also the supplier for the process that follows. Parts and materials from one process are sent on to the next process only when requested and in the quantity requested. This is facilitated by **kanban**, cards that carry information from one process to the preceding process about what and how much to produce next. For example, a container carries parts to a worker on the assembly line. The container has a kanban attached to its side. The kanban identifies the type of part, how many there are, and other basic information. When the parts have been used, the empty container is sent back. The kanban indicates that the parts have been "sold" and that more needs to be produced. With kanban, each process "pulls" only the parts it needs. It eliminates the need for keeping

huge inventories because it fills only immediate demands. If a defective part is identified, the problem can be corrected immediately and the supplier notified before making any more parts.

In mass production, the discovery of a defective part may mean that thousands of defective parts are stored on supply shelves. Months might have passed since the parts were received from the supplier, and so correcting the error will be time consuming and costly.

Building in Quality

Built-in-quality through automatic line stops is another innovation introduced at Toyota. In this system, equipment is designed to stop automatically when a defect is identified or a problem occurs. This process also involves workers who are encouraged to stop the assembly line when defects are discovered or a problem arises. Workers and supervisors resolve problems on the spot. The line is then put back into operation. Built-in quality prevents little problems from becoming big problems. It helps improve the quality of a product and eliminates the need for quality inspectors and rework teams. It also ensures that machines work for people, not the other way around. It eliminates the wasted time involved when workers watch machines to ensure that the machines don't malfunction.

Kaizen: Continuous Improvement

Lean production also embodies the principle of **kaizen**, or continuous improvement. Kaizen involves improving both work procedures and equipment. It is an on-going process involving a variety of activities to reduce waste and inefficiency. Here are some examples of kaizen in practice.

Wasted worker movement that doesn't contribute to work

Problem: Ed had to retrieve a part from his workbench and then bend to fit it to the bottom of a car. The wasted movement in retrieving and bending added to the time Ed spent on each car. It also strained Ed's back.

Solution: Ed thought that he needed to use something like a rowboat that would allow him to get under the car quickly. At Ed's suggestion, he and his coworkers devised a low device with wheels that allows Ed to move under each car and install the part easily.

Inefficient movement of parts and materials through the factory

Problem: The bindery at a printing press was located at one end of the factory. Completed books had to be transported across the factory to be bound. Time and effort were wasted carting the books back and forth.

Solution: Janet recommended moving the binding machines closer to the printing process in order to cut down on the production time. It did.

Spending more time or effort on processing than is actually useful

Problem: A car manufacturer challenged employees to find a way to make one of their models $100 cheaper to produce. Employees examined auto parts and looked for ways that the parts could be assembled more efficiently.

Solution: Gene devised an improvement that prevented workers from mounting a part backward. This and several other ideas resulted in the reduction of the car's cost and the awarding of bonuses to the employees.

Employees work together to solve problems that occur on the assembly line.

Many kaizen activities are done as a group effort. Employees, working in teams, set aside time to review work procedures and to come up with ways of enhancing their performance. These group efforts are known as **quality circles**.

Kaizen improves the quality of the product and the logistics of the production process. It also gives employees a feeling of empowerment in and ownership of their jobs by allowing them to take responsibility for their work in ways that improve their own working conditions and to the quality of the product they are producing.

Profiles

Abe Padilla
Production Inspector
Toyota Motor Corporation

"I look forward to coming in every day. I have never missed a day. I have never been late." Abe Padilla is an inspector for Toyota, the original and widely emulated pioneer of just-in-time production. Abe's job is to do a final check of the autos to make sure the right parts have been put on and the job has been completed.

In 55 seconds flat, Abe and other members of his team test and inspect a new car's brake lights, accelerator, radio, air conditioner, and other items. "If I find any kind of safety problem, I pull the andon line, a cord above my head," says Abe. The andon cord activates a light and a bell that alert the team leader. If Abe and the team leader cannot solve the problem within the next 55 seconds, the assembly line shuts down.

Before being hired by Toyota, Abe was screened for his ability to work under pressure and to work with a group. His college education and experience in the Marine Corps helped qualify him for the job. "A lot of people can't cope under constant, steady pressure," says Abe, "not having the time to step back and take a breather."

Abe likes working under the just-in-time system. "I have the power to stop the line," he remarks. "That's great for morale. I know that somebody cares. I know that I have an impact on what happens."

Think about your own ability to work as part of a team. Do you work well with others?

Michele Demler
High School Apprentice
Post Printing Company

When Michele Demler leaves West Bend High School at noon, she's not off to play hooky. She's off instead to the Post Printing Company, where she spends three hours each day acquiring the essential skills of color process printing. The printing company is one of many participating in the Printing Youth Apprenticeship, an innovative program for Wisconsin high school students.

"I'm learning everything about printing," explains Michele. "I help set up the press, load the feeder, put the inks in, position the plates, and wash up the presses afterward. As a consumer, you don't appreciate the work that goes into a printed piece. But I see first hand what goes into the finished product."

Michele's morning classes include technical prep courses in chemistry, word processing, and graphic arts which provide her with many of the skills she needs to work at the press. She also gets on-the-job training from pressworkers and Jeannie Ott, a supervisor.

Working in the program while attending school enables Michele to keep her educational alternatives open. After graduation, Michele could work at the printing press full time and receive a good salary. She also could attend Moraine Park Technical College with the option of going on to the University of Wisconsin. Meanwhile, she is already receiving college credit for two of the courses she is taking.

What skills and information do your courses provide you with that will be helpful in your chosen career?

Profiles

Sam Johnson
Wage Trainer
John Deere Harvester Works

"There are a lot of barriers coming down. Cooperation is tremendous now. It started to change dramatically seven or eight years ago," says Sam Johnson, describing his job at John Deere.

Sam, who joined John Deere after graduating from high school, has worked his way up from tractor driver to parts shipper to assembly line worker to inspector to his present position as wage trainer.

In his present job, Sam teaches other Deere employees the ins and outs of teamwork and communication. Sam believes that his work will help improve the level of job satisfaction and the quality of the complex, heavy equipment that John Deere manufactures. "The concept of the whole plant is changing in relation to quality," he notes. "What customers are looking for today is value. If they don't get it, they will buy from competitors, stateside or foreign."

Until a decade ago, many of John Deere's products were developed with no input from workers. Today Deere's engineering groups use suggestions and recommendations from workers when they develop products. "Management makes you feel that you're part of the team," says Sam. "They encourage people on the floor to offer ideas and, yes, they do listen."

What job do you plan to pursue? What communication skills are necessary for that job?

Sheila Cody Peterson
Total Quality Manager
Foxboro Corporation

"When I elected to go into manufacturing, it met a lot of my personal needs," confides Sheila Cody Peterson. "I have a technical side as well as a desire to use interpersonal skills."

While at college, Sheila worked summers at the Foxboro Corporation. Today, as Foxboro's total quality manager, she promotes customer focus, continuous improvement, and communication among employees and helps them establish goals and improve their problem-solving skills.

Foxboro manufactures devices that measure and control various industrial processes. The company's success in recent years is due largely to creating an environment in which employees are encouraged to work together. One of Sheila's tasks is to help workers create Quality Improvement Process Teams. "The value of teamwork is to optimize results," explains Sheila. "You need to bring people together to find innovative solutions that allow you to remain competitive."

Employees learn to approach problem solving in a structured, logical way. Learning statistics, for example, helps them analyze data. They also learn about group dynamics, with an emphasis on mutual respect and learning how to listen to customers and one another. "We use the whole person these days," says Sheila, "not just his or her dexterity."

"In my vision," says Sheila, "work in manufacturing is a great way to improve the economy and the quality of life in the United States. You can have a lot of impact."

What problem-solving skills do you possess that will help you in your future career?

Preparing for the Factory Visit

Introduction

Visiting a factory is the practical aim and high point of the *What's Up In Factories?* curriculum unit. It offers your students the opportunity to view on site and in action many of the innovations presented in this resource guide. For you as a teacher as well as for your school, it will create a valuable and quite possibly enduring link with the local business community. We hope you will find the entire process—from contacting an appropriate factory to examining your students' reactions afterward—to be a rewarding and memorable experience.

Conducting a successful factory visit involves five basic steps

Locating an appropriate factory
Setting up the visit
Preparing your students
Visiting the factory
Following up

These are explained in detail on the following pages.

Locating an Appropriate Factory

Although there are more than 500,000 manufacturing facilities in the United States, choosing an appropriate factory will take some time and effort. Many factories welcome high school groups. From management's point of view, a guided tour of the facilities is an effective and inexpensive form of community relations that generates good will and offers an opportunity to express company pride. It is also a chance for the company to let students know what career choices may be available, together with job descriptions and educational requirements.

When looking for a factory, try to find one that uses state-of-the-art equipment and that reflects today's technology. Factories that produce consumer products, such as cars, appliances, and entertainment equipment will be of more interest to students than factories that produce industrial products such as bolts or screws.

To locate an appropriate factory, begin with nearby resources. Colleagues may know of or have toured factories in your area. Students may have parents working at factories where tours are conducted. Students may also be assigned to do initial research locating factories in your area. Such a research assignment will not only provide a greater number of possible sites, but will also help students better understand the economic base of their community.

You might also consider contacting national umbrella organizations (see pages 22-23) such as the Society of Manufacturing Engineers that can help you locate factories in your area. Your local Chamber of Commerce and your city or state tourist or convention bureau can also provide useful information about manufacturers. Another possible resource is the Business-to-Business Yellow Pages.

When you have a list of possible visitation sites, go through it and choose two or three to contact.

Setting up the Visit

When you contact factories, you should ask to speak to the departments of human resources, public relations or, in some cases, personnel. Be ready to provide certain information and to ask key questions.

Prepare in advance a list of possible dates and times for your class visit. Also, have some idea of how many students and adults will be going on the trip. Although your entire class will tour the factory, many companies ask that larger classes do the tour in small groups of ten to twelve. Some factories receive visitors regularly, and may even have a formalized tour. Others give tours in response to individual requests. When scheduling you may want to ask other questions to help you prepare for the visit.

How long will the tour take?

The entire visit should last fewer than two hours. Knowing its duration will allow you to schedule transportation, lunch, departures, and returns. You may also want to find out whether a lunchroom facility is available for your use.

Can you send me information about your factory?

Companies may be able to provide you with brochures, handouts, or other materials. Some manufacturers may offer to send you a short video about their manufacturing process.

Are there any special safety instructions?

Each factory will has its own set of rules that students will be expected to follow. They will need to wear appropriate shoes and clothing. (High heels, sandals, and open-toed shoes are not acceptable.) In addition, they may be asked to wear special gowns, shoe coverings, caps, or safety glasses.

May I visit the factory before the trip?

If your schedule permits, a preview of the factory will give you a chance to meet personnel and observe the manufacturing process. This will allow you to be prepared for the class visit.

Preparing Your Students

The lessons in this guide provide a general approach for understanding what goes on in most manufacturing plants. In addition to this, you will want to share with students whatever materials you have received from the manufacturer.

You will also want to point out to students that they are guests of the factory and that they will need to act responsibly. Discuss the following safety points with them.

1. Obey the tour guide's directions. Stay with the group at all times; do not straggle.
2. Walk areas in a factory are marked. Stay within the boundaries of marked walk areas.
3. Do not distract workers or interfere with their work. Do not touch tools, machinery, or parts or take "souvenirs."

Visiting the Factory

The factory visit can be treated as a lesson similar to other lessons in this guide.

Students will

- observe and experience the manufacturing process on site;
- follow the manufacture of an item from raw materials to finished product;
- determine whether manufacturing innovations such as just-in-time, kanban, and kaizen have been introduced;
- identify the tasks performed by workers;
- analyze job skills and educational requirements necessary for employment.

Before the visit, duplicate and distribute Student Activity 6, The Factory Visit, to students (page 20). Have them fill out the top of the page, and review questions with them. Students should not take this sheet along with them since they will be busy observing factory operations and listening to the tour guide to complete it. For safety reasons, it is not a good idea to walk through a factory while jotting down notes. Students may write down observations and answers to the activity sheet questions directly after the tour or upon returning from the tour.

Following up

After the factory visit, provide time for students to give their impressions and observations. Have them share their responses to the material on Student Activity 6.

Students who wish to do further reading or activities associated with manufacturing should be referred to the Bibliography (page 24) and to the Student Projects page (page 21).

photo Joseph P. Sinnott

The Factory Visit

Name of the factory:

Product or products manufactured:

Number of employees:

1. List in order the processes used to manufacture the product. For each process, list the machines involved and briefly describe the job of each worker involved in that process.

2. What specific jobs do people perform? What educational level and skills are required for each job? Does the company provide training for its employees? What is the pay range for workers at the factory?

3. Did you see evidence of new trends such as just-in-time, kanban or built-in quality? Explain.

4. What kind of information needs to be communicated in this factory? How was information communicated?

5. What communications skills and mathematical skills are needed by various personnel in the factory?

6. What impressed you the most about the factory? the least?

7. How did visiting the factory and studying the manufacturing process affect the way you view manufactured products?

STUDENT PROJECTS

These research projects may be assigned to students as homework assignments or as extra credit projects. Students may work alone, with a partner, or with a group.

Packaging a Product

Almost all products are packaged. Materials such as plastics and cardboard are used to protect and to display items ranging from toys to batteries to food. Have students examine the packaging of an item with the goal of reducing the size of the package and making the package more environmentally sound. Students should first take the package apart and identify the various materials used to make the package (cardboard, Styrofoam, plastic windows, labels, adhesives, etc.). Then have them redesign the package so that it is smaller and is made of environmentally safe materials but retains its attractiveness to the consumer. Students might take their redesigned product to a supermarket and survey shoppers about which packaging they prefer and why. Have students present their findings to the rest of the class.

Changing the Factory for the Better

In Lesson 4, students learned about some of the new trends in manufacturing. During the factory visit, students might have identified areas that would benefit from the introduction of some of these new systems and processes such as built-in-quality, kaizen, kanban, or other innovations. Have students work in groups to brainstorm ways in which the factory they visited might improve the arrangement of machines, the delivery of information, the distribution of supplies, and so on, and present their ideas to the rest of the class.

If students have not visited a factory, explain that they can apply these concepts to other settings such as the kitchens in their homes. Have each student draw a floor plan of the kitchen and interview a parent or other person who uses it most to find out whether he or she has any complaints about the layout. Students should then try to redesign the kitchens to incorporate more efficient layouts and present their ideas to the rest of the class.

The Job Interview

Have each student write a "help wanted" ad for a job in manufacturing. The ad should be as descriptive as possible, listing responsibilities, qualifications, and salary range. Post students' advertisements on a bulletin board, and invite each student to apply for the job that interests them. Students who have posted the jobs could interview applicants. The purpose of the interview is to determine which candidate possesses the best skills for each job. Interviewers may want to consider whether each applicant is a "self-starter" and a "problem solver." Candidates should be prepared to describe their educational backgrounds, the skills that they possess, and other jobs they have had, and suggest to students ways in which they would tackle problems they encountered on the job.

The Five Whys

Taiichi Ohno, an innovator who developed the manufacturing process called the Toyota Production System, encouraged workers to ask the question "Why?" five times in order to solve problems they encountered on the job. For instance, if a worker noticed that a part did not fit properly, he or she would use the "Five Whys" to trace the problem from its obvious symptoms to its origin. The same principles can be used in daily life. For example, a student might use the "Five Whys" to discover why a cake did not bake properly. Problem: The cake was undercooked in the center. Why? Because the oven temperature was too low. Why? Because the baker kept opening the oven door to check on the cake's progress. Why? Because the oven light wasn't working, so it was too dark to see inside the oven without opening the door. Why? Because the bulb had burned out and wasn't replaced. Why? Because there were no light bulbs on hand. Solution: Buy two bulbs for the oven. Install one and keep an extra one on hand.

Challenge students to work alone or in teams to identify a problem in school or the community and apply the "Five Whys" to find a solution.

Who's the Best?

The Malcolm Baldrige National Quality Award is given each year by the U.S. Commerce Department to businesses that demonstrate themselves to be of "world-class quality." Some recipients include Motorola, Eastman Chemical, and AT&T. Have students research the criteria for being eligible for the award and the ways in which the winners are chosen. Ask students to research companies that have received the award and report on why those companies were selected. If they were the judges, which companies would they choose? Encourage students to discuss their views with the rest of the class.

The following list includes organizations, publications, and science and technology centers that teachers may wish to consult in extending their study of factories and manufacturing.

MANUFACTURING AND ENGINEERING ORGANIZATIONS

The Association for Manufacturing Technology
7901 Westpark Drive
McLean, VA 22102
(703) 827-5219

A nonprofit trade association representing companies in the machine tool and related manufacturing technology industries in the United States. Offers career guidance materials. Hosts biggest manufacturing trade show in the world (in Chicago, held bianually); free registration for students and faculty. AMT member companies sponsor tuition scholarships at regionally accredited public community, junior, or technical colleges.

Institute of Industrial Engineers
25 Technology Park/Atlanta
Norcross, GA 30092
(404) 449-0460

Professional society of industrial engineers and student members. Offers publications and sponsors high school competitions.

National Action Council for Minorities in Engineering (NACME)
3 West 35th Street
New York, NY 10001-2281
(212) 279-2626

Seeks to increase the number of African Americans, Hispanics, and Native Americans enrolled in and graduating from engineering schools. NACME is a not-for-profit corporation that conducts research and public policy analysis in education, provides scholarships, develops and operates national demonstration programs, and publishes original educational materials.

National Center for Manufacturing Sciences
3025 Boardwalk
Ann Arbor, MI 48108
(313) 995-0300

Consortium of corporations committed to making North American manufacturing globally competitive through the promotion of next-generation manufacturing technologies. Developed the Industrial Fellowship Program, in which teachers spend six weeks on the factory floor so that they can prepare their students for careers in manufacturing, and the Manufacturing Technology Laboratory Program, in which mobile laboratories take state-of-the-art technologies to schools.

Robotics Industries Association
900 Victors Way
P.O. Box 3724
Ann Arbor, MI 48106
(313) 994-6088

Advances use of robot technology in the United States. Provides publications, films, and videos on robotics.

Society of Automotive Engineers
400 Commonwealth Drive
Warrendale, PA 15096-0001
(412) 776-4841

Society of engineers, scientists, and engineering students in the field of self-propelled vehicles. SAE has an ongoing interest in improving math and science education in the United States. Its initiatives range from World in Motion, a science-enhancement program for grades 4-6, to undergraduate engineering scholarships.

Society of Manufacturing Engineers
P.O. Box 930
1 SME Drive
Dearborn, MI 48121
(313) 271-1500

Professional society of manufacturing engineers, practitioners, and management executives concerned with manufacturing technologies for improved productivity. Local chapters may provide contacts for teachers seeking to organize field trips to factories.

Society of Plastics Engineers
14 Fairfield Drive
Brookfield, CT 06804-0403
(203) 775-0471

Professional society of plastics scientists, engineers, educators, students, and others interested in the design, development, production, and utilization of plastics materials, products, and equipment. Provides free taping of "Not Your Average Field Trip," a 19-minute classroom video program on modern plastics.

Society of Women Engineers
120 Wall Street, 11th Floor
New York, NY 10005-3902
(212) 509-9577

Seeks to inform young women, their parents, counselors, and the general public of the qualifications and achievements of women engineers and the opportunities open to them. Offers career guidance, publications, and scholarships.

PRE-ENGINEERING AND TECHNOLOGY ORGANIZATIONS FOR STUDENTS

Junior Engineering Technical Society (JETS)
1420 King Street, #405
Alexandria, VA 22314-2715
(703) 548-JETS

Society for high school students interested in math, science, technology, and engineering; chapters in 50 states. JETS is also an excellent source of books, brochures, videotapes, and curriculum kits for teachers.

Technology Student Association
1914 Association Drive
Reston, VA 22091
(703) 860-9000

Association of elementary, junior high, and senior high school technology education students who are enrolled in or have completed technology education courses. Goals are to help students make informed decisions about jobs through experiences in technology programs and to help prepare them for entry into technology-related careers. Sponsors Technology Honor Society. Offers *Technology Teacher's Guide*, brochures, and flyers.

SCIENCE AND TECHNOLOGY ORGANIZATIONS FOR EDUCATORS

American Association for the Advancement of Science
1333 H Street, NW
Washington, DC, 20005-4792
(202) 326-6400

Seeks to further the work of scientists, to improve the effectiveness of science in promoting human welfare, and to increase public understanding of science and technology.

International Technology Education Association
1914 Association Drive
Reston, VA 22091
(703) 860-2100

Association of technology education teachers and supervisors in elementary, secondary, and higher education. Publications include *Journal of Technology Education* and *Technology Teacher*.

National Association of Industrial Technology
3157 Packard, Suite A
Ann Arbor, MI 48108-1900
(313) 677-0720

Association of industrial organizations, administrators, industrialists, educators, students, and graduates of industrial technology programs. Publishes directory of manufacturing programs offered at colleges and junior colleges.

National Association for Science, Technology, and Society
133 Willard Building
Pennsylvania State University
University Park, PA 16802
(814) 865-3046

Educational organization that seeks to create a technologically and scientifically literate citizenry, to integrate the humanities and social sciences into science and technology programs, to help shape public policy that guides technology, and to introduce STS education into the mainstream. Offers publications, video modules, and programs for industry involvement in education.

PUBLICATIONS FOR TECHNOLOGY EDUCATORS

TIES Magazine: Technology, Innovation and Entrepreneurship for Students
Trenton State College
3 Armstrong Hall
Hillwood Lakes
CN4700
Trenton, NJ 08560-4700
(609) 771-3333

A cooperative, nonprofit publication for teachers interested in helping students increase their technological literacy and capability. Drawing on information from industry, business, government, and education, TIES provides teachers with up-to-date resources for the development of a hands-on, problem-solving technology education curriculum.

MUSEUMS AND SCIENCE-TECHNOLOGY CENTERS

For more information about science and technology museums in your area, you can check *The Official Museum Directory 1994*, 24th Edition, New Providence, N.J.: R.R. Bowker, 1993. Also you may contact the Association of Science-Technology Centers (ASTC):

Association of Science-Technology Centers
1025 Vermont Avenue, NW, Suite 500
Washington, DC 20005
(202) 783-7200

Baltimore Museum of Industry
1415 Key Highway
Baltimore, MD 21230
(410) 727-4808

The museum's collections include machinery, workplace, and labor artifacts and exhibits on the history of Maryland industry, technology, and labor.

Edison National Historic Site
Main Street at Lakeside Avenue
West Orange, NJ 07052
(201) 736-0550

The Edison National Historic Site features 20 historic structures dating from 1880-1887, including the Glenmont home and laboratory of Thomas Edison. Its collections include industrial and scientific machinery and equipment, the Edison Archives, photographs, and sound recordings.

The Exploratorium
3601 Lyon Street
San Francisco, CA 94123
(415) 563-7337

The Exploritorium's 650 participatory exhibits and works of art illustrate the physical nature of the world and the sensory mechanisms through which we perceive the world.

Fashion Institute of Technology
227 West 27th Street
New York, NY 10001
(212) 760-7601

FIT's collections include one million articles of dress dating from the seventeenth century to the present. It also has a CAD facility that school classes may visit by special appointment.

Franklin Institute Science Museum
20th & the Benjamin Franklin Parkway
Philadelphia, PA 19103-1194
(215) 448-1200

The exhibits focus on a wide range of science-related topics, including industry, history, technology, transportation, aeronautics, astronomy, space exploration, energy, and mathematics.

Henry Ford Museum & Greenfield Village
20900 Oakwood Boulevard
Dearborn, MI 48124
(313) 271-1620

This history museum's collections include more than a million artifacts from American history and technology. Its 12 acres of exhibit space feature 80 historic structures.

Museum of American Textile History
800 Massachusetts Avenue
North Andover, MA 01845
(508) 686-0191

The museum's collections include tools, machines, prints, photographs, business records, industry periodicals, textiles, swatches, sample books, trade catalogs, and books.

The Louisville Science Center
727 West Main Street
Louisville, KY 40202
(502) 561-6103

The Louisville Science Center is a hands-on science center and natural history museum. Its collections are devoted to science, technology, space science artifacts, history artifacts, and archaeology findings.

Museum of Science and Industry
57th Street and Lake Shore Drive
Chicago, IL 60637
(312) 684-1414

The museum offers participatory exhibits that depict technological applications, scientific principles, and social implications in the fields of energy, publishing, transportation, agriculture, communications, space exploration, photography, aerospace, medicine, chemicals, food, chemistry, and physics.

National Museum of American History
Smithsonian Institution
Washington, DC 20560
(202) 357-1300

The museum's exhibits focus on engineering and industry, computers, textiles and transportation, agriculture and natural resources, electricity and modern physics, graphic arts, medical sciences, armed forces history, ceramics and glass items, community life items, costumes and dress, and domestic life.

Ohio's Center of Science and Industry
280 East Broad Street
Columbus, OH 43215
(614) 228-2674

The center offers four floors of hands-on, interactive exhibits, including physical science, earth science, travelling exhibits, and health/life science. An exhibition specifically aimed at high school students examines the chemistry of everyday consumer items.

The following books, articles, and films may be of interest to you and your students. You may wish to duplicate the bibliography/videography and distribute it to your class.

Cohen, Stephen S., and John Zysman. *Manufacturing Matters: The Myth of the Post-Industrial Economy*. New York: Basic Books, 1988. A study by two Berkeley economists that explores the importance of manufacturing in the American economy.

Dertouzos, Michael L., Richard K. Lester, and Robert M. Solow. *Made in America: Regaining the Productive Edge*. New York: HarperPerennial, 1990. A critical assessment of how America does business by M.I.T.'s Commission on Industrial Productivity.

Fisher, David. *What's What: The Visual Glossary of the Physical World*. Maplewood, N.J.: Hammond, Inc., 1991. Detailed views of everything from cameras to toasters to espresso machines.

Goldratt, Eliyahu M., and Jeff Cox. *The Goal: A Process of Ongoing Improvement*. Croton-on-Hudson, N.Y.: North River Press, 1992. A novel that discusses how new global principles of manufacturing can be used to prevent the decline of manufacturing in the West.

Hamilton, Stephen S. *Apprenticeship for Adulthood: Preparing Youth for the Future*. New York: The Free Press, 1990. Presents reasons for instituting apprenticeship programs to prepare students to be the workforce of the future and help them develop into adulthood.

Jaspersohn, William. *Motorcycle: The Making of a Harley-Davidson*. Boston: Little, Brown,1984. An account of how a motorcycle is made from its initial design to manufacture at the plant.

Macaulay, David. *The Way Things Work*. Boston: Houghton Mifflin, 1988. From levers to lasers, from cameras to computers, this book presents an overview of machines and inventions that shape our lives.

Meltzer, Milton. *Bread and Roses: The Struggle for American Labor, 1865-1915*. New York: Facts on File, 1990. A history of how labor organized in America.

Nothdruft, William E. *Schoolworks: Reinventing Public Schools to Create the Workforce of the Future*. Washington, D.C.: Brookings Institution, 1990. Profiles innovative programs in education and job training in France, Great Britain, Sweden, Germany, and America and presents ideas on strengthening America's workforce.

Ohno, Taiichi. *The Toyota Production System*. Cambridge, Mass.: Productivity Press, 1988. Features the story of and principles that guided the innovator who developed lean production.

Reid, Peter C. *Well Made in America: Lessons from Harley-Davidson on Being the Best*. New York: McGraw-Hill, 1990. An account of how an American company used just-in-time manufacturing to become a success.

Womack, James P., and Daniel Roos. *The Machine That Changed the World: The Story of Lean Production*. New York: HarperBusiness, 1991. Based on M.I.T.'s five-million-dollar, five-year study on the future of the automobile, an account of the worldwide move from mass production to lean production.

ARTICLES

Chappell, Linsay. "Toyota Spreads Gospel of Efficiency." *Automotive News*, January 24, 1994, p. 16.

Donnelly, Brian. "Green Product Design." *TIES Magazine*, September/October 1993, pp. 48-55.

"The New Century: The People, Ideas, and Technologies Making the U.S. More Competitive Now — and for the Year 2000." *Fortune*, Special Issue, Spring/Summer 1991.

Rosenstock, Larry. "Reunifying Academics and Vocational Education." *The Educational Digest*, May 1991, pp. 22-25.

Stalk, George, Jr. "Time — the Next Source of Competitive Advantage." *Harvard Business Review*, July 1988, pp. 41-51.

Tyre, Marcie J. "Managing Innovation on the Factory Floor." *Technology Review*, October 1991, pp. 58-65.

Weber, Robert. "Goodbye Mr. Ford, Hello Mr. Toyoda." *TIES Magazine*, November/December 1992, pp. 31-34.

Zipkin, Paul H. "Does Manufacturing Need a JIT Revolution?" *Harvard Business Review*, January/February 1991, pp. 40-50.

FILMS

Challenge to America
VHS, 240 min. 1994. Distributed by Films for the Humanities and Sciences, Princeton, N.J.
(800) 257-5126

The Deming of America
VHS, 57 min. 1993. Distributed by Films, Inc., Chicago, Ill.
(800) 323-4222 ext. 44

The Life and Times of Rosie the Riveter
16 mm and VHS, 65 min. 1980. Distributed by Direct Cinema, Santa Monica, Calif.
(800) 525-0000

Sit Down and Fight—Walter Reuther and the Rise of the Auto Workers' Union
VHS, 60 min. 1993. Distributed by PBS Video, Alexandria, Va.
(800) 344-3337

We Do the Work: #403 Leaving Home
VHS, 30 min. 1992. Distributed by California Working Group, Oakland, Calif.
(510) 547-8484

GLOSSARY

AFL (American Federation of Labor) an organization of skilled workers belonging to national trade (craft) unions. Founded in 1886, its goals were to gain better conditions such as higher pay and a shorter working day for workers.

arbitration: a technique by which an impartial third party works with the disputing parties (such as the United Autoworkers Union and the auto industry) to resolve a conflict.

assembly line: an arrangement of machines, equipment, and workers that permits the easy assembly of a product as it passes from process to process.

built-in quality: a system in which workers or equipment can stop the production process automatically when a defect is identified or a problem occurs.

casting: a process in which an industrial material is first made into a liquid and then poured or forced into a prepared mold, allowed to solidify, and finally removed from the mold.

chemical process: a method that uses chemical or thermal reactions to process raw materials. Plastics, for example, are formed by chemical reactions.

CIO (Congress of Industrial Organizations) An organization of unskilled workers founded in 1938 by former AFL leader John L. Lewis. Its goals were to gain increased pay, better working conditions, and the right to bargain collectively.

division of labor: a manufacturing method in which workers perform one or two steps in the production process rather than make a product from start to finish.

engineering: the art or science of making practical application of the knowledge of physics, chemistry, biology, etc.

factory: a building or set of buildings containing all the machinery and tools necessary for manufacturing a product.

forming: a process that changes the size and shape but not the volume or weight of a material.

Great Depression: the economic collapse of the 1930s that affected all aspects of American life. It was spurred by the fundamental economic instability of the 1920s and the resultant stock market crash of 1929.

just-in-time: a system of production in which each process or step produces only the kinds and quantities of items for immediate use in the next process or step.

kaizen (KAI-zehn): an ongoing improvement process involving a variety of activites designed to reduce waste and inefficiency.

kanban (KAHN-bahn): a card that travels with supplies from process to process. The kanban carries information about what and how much to produce next.

Knights of Labor (The Noble and Holy Order of the Knights of Labor): an organization of skilled and unskilled workers that was founded in 1869 by Uriah Stephens. Open to men and women of all races, its goals included the adoption of industrial safety measures, a law mandating weekly pay, equal pay for equal work for both sexes, and arbitration instead of strikes.

lean production: (See **just-in-time**.)

manufacturing: from the latin *manu factus* ("made by hand"); the process of making a product by hand or by machinery.

mass production: a system of production in which large quantities of a product are made quickly by using interchangeable parts.

mechanical process: a method that uses mechanical force such as cutting or crushing to change the form of a material.

prototype: a working model of a product that is used in tests and experiments designed to determine how the product will perform.

quality circle: a group of workers who meet to discuss how to improve the way in which they work together, the products they make, and other aspects of production.

separating: processes that remove excess material to change the size, shape, or surface of a part. Two aspects of separating are machining and shearing.

technology: a scientific method of achieving a practical purpose; the totality of the means employed to provide objects necessary for human sustenance and comfort.

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New York, N.Y. 10019